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CALIFORNIA ENERGY FLOW IN 1976

I. Y. Borg

April 20, 1978

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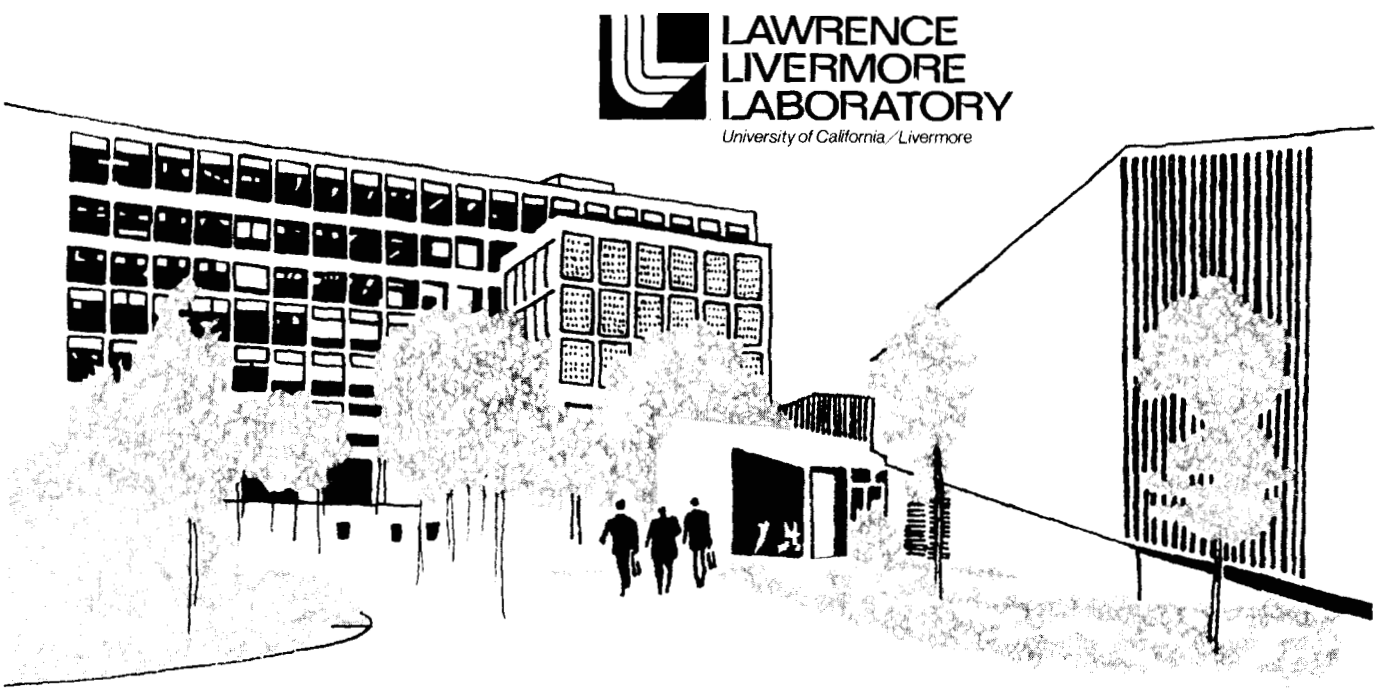

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ABSTRACT

We present here a diagram of energy flow in California in 1976 and compare it with a similar analysis of energy flow in 1974. The comparison indicates that California's consumption of natural gas has decreased by about 10%, oil imports have increased by 25%, and total oil consumption has increased 13%. Because of the drought, hydroelectric power production has fallen 37%, and power imports have risen 65%. Residential/commercial and transportation end uses have risen, while industrial use has decreased 10% as a result of the 1975-76 recession, which was associated with a 9-11% unemployment rate in California.

HIGHLIGHTS

Energy flow charts are of value in two principal ways. First, they display assessments of energy supply and usage in such a way that the data can be synthesized and understood quickly; an overall view of a complex series of relations is thereby greatly facilitated. Secondly, they permit ready comparisons between states, regions, or nations either currently or historically.

It is possible to embellish flow charts with a great deal of information to maintain accuracy. The 1975 chart* prepared by the California Energy Commission (CEC) [1] is one example. On the other hand, oversimplification can result in a loss of important information. The 1976 chart contained here is patterned after the 1974 Behrin and Cooper constructions,[2] and it embodies their point of view regarding what information is pertinent. It is less complex than the 1975 CEC diagram,[1] but more detailed than other diagrams[3,4] that have been constructed for California. In the present construction, the data were collected from the California Energy Commission, the California Division of Oil and Gas, and (to a lesser extent) the U.S. Bureau of Mines.

The 1976 diagram is shown in Fig. 1. The 1974 Behrin and Cooper construction is shown in Fig. 2. Comparison of the two figures (Table 1) reveals the following:

- Use of all but one primary energy source (natural gas) increased ~12% over the 2-year period.
- Natural gas consumption fell almost 10% because of a 40% reduction in industrial use.
- Crude oil and NGL imports increased almost 25%, and California production increased slightly.
- Although coal use increased in California, from the standpoint of volume, it remained an unimportant fuel.
- Residential/commercial, transportation, and "non-energy" end-uses (including petrochemical uses of fossil fuels) all increased.
- The 10% drop in industrial consumption of all fuels was related to the 1975-76 recession, which was associated with a 9–11% unemployment rate.[5]

*Based on 6 months actual and 6 months projected data for 1975.

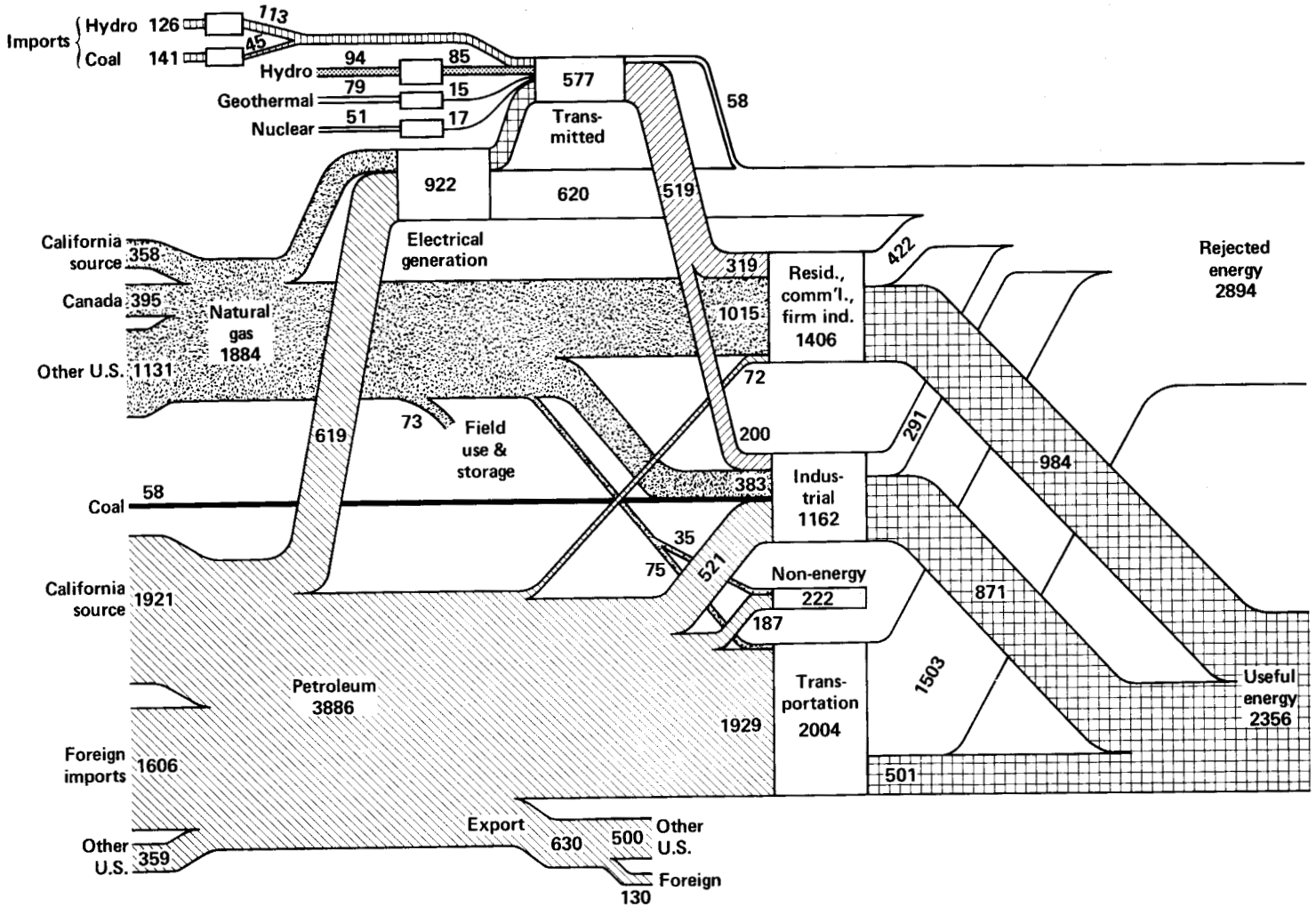
SOURCES OF DATA AND ASSUMPTIONS

Energy Sources

Oil and Natural Gas Liquids

California crude oil production, as presented in Fig. 1, includes approximately 14 million barrels from federal offshore fields. It also includes liquid petroleum gases (LPG), lease condensate, and condensate from gas-processing plants. All of the data are from the California Division of Oil and Gas.[6] Foreign imports[7] consisted primarily of crude oil (267.98 million barrels), with some additional residual oils and aviation fuel (8.41 million barrels). Im-

Total Energy Consumption 5700 X 10^{12} Btu



Data: California Energy Commission; California Division of Oil & Gas, U.S. Bureau of Mines.

Fig. 1 California energy flow, 1976 (10^{12} Btu).

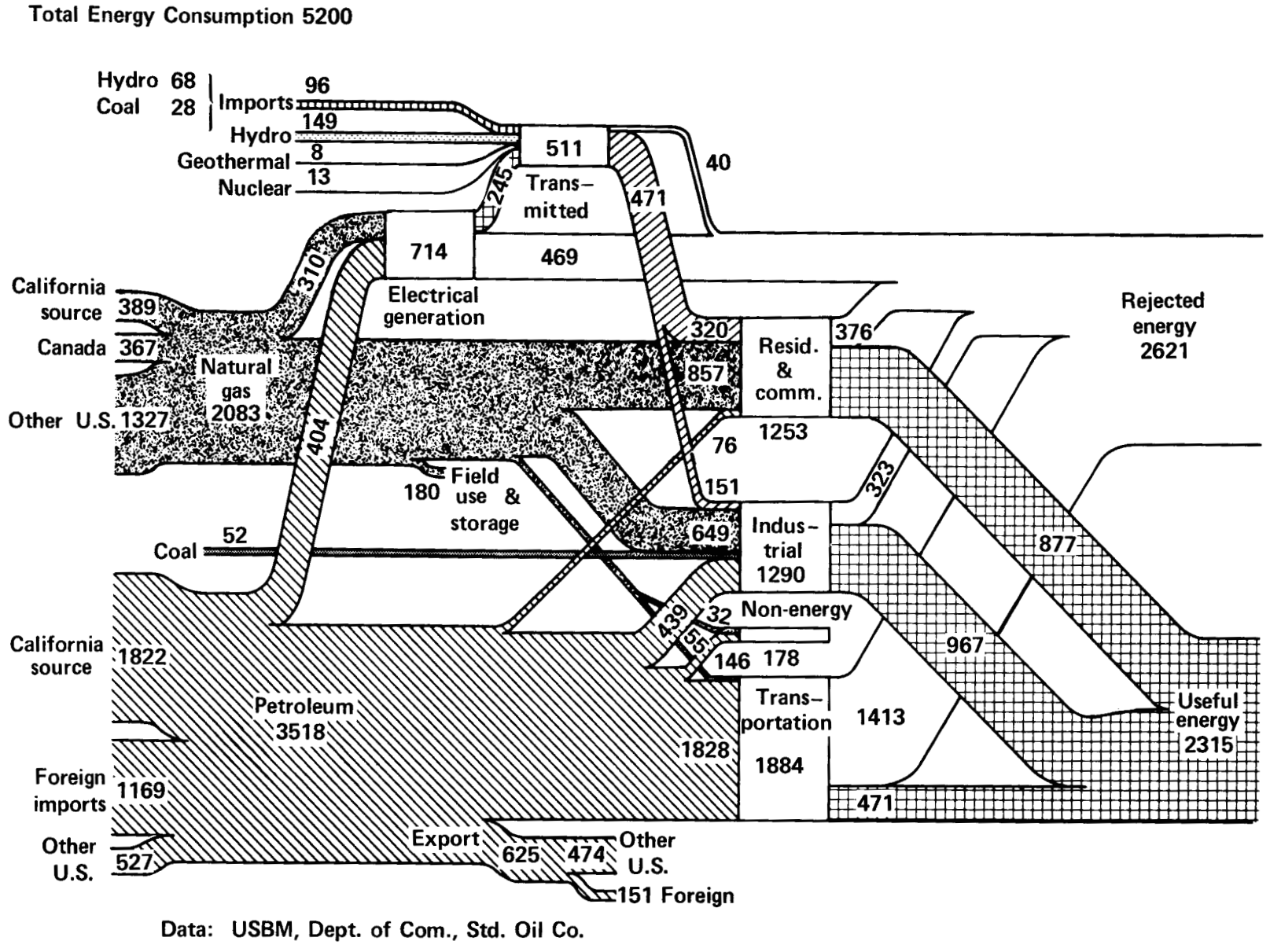


Fig. 2. California energy flow, 1974 (10^{12} Btu).

Table 1. Energy use in California, 1974 and 1976.

	Energy use, 10^{12} Btu		
	1974	1976	Percent change
Electricity transmitted	511	557	+12.9
Natural gas consumed	2083	1884	-9.6
Coal consumed in CA	52	58	+11.5
Crude oil and NGL			
Production in CA	1822	1921	+5.4
Gross imports	1696	1965	
Less exports	625	630	
Net imports	1071	1335	+24.6
Total	2893	3256	+12.5
End use			
Residential/commercial/firm-industrial	1253	1406	+12.2
Industrial	1290	1162	-9.9
Nonenergy[a]	178	222	+24.7
Transportation	1884	2004	+6.4

[a]See text for make-up.

ports from other states were almost equally divided between crude oil and products.[7,8] Exports from California to other states were primarily gasoline, aviation fuel, and heavy oils; foreign exports were almost entirely residual oils.[7]

Natural Gas

Data on California production of both associated (160.6 MCF) and nonassociated (174.6 MCF) as well as federal offshore gas (5 MCF) were derived from the California Division of Oil and Gas. In contrast to data codified by the CEC, [7] these data include all producers. Production has been decreased by the amount of gas blown to air. Also, in contrast to CEC practice, reinjected gas is not included in production. Import data are given in Table 2.[9]

Table 2. California natural gas imports in 1976.[9]

Company	Imports, MCF
El Paso Natural Gas (Texas-Oklahoma)	886.5
Pacific Interstate Transmission Co.	1.15
Transwestern Pipeline Company (New Mexico)	189.6
Pacific Gas Transmission Co. (Canada)	375.8

Coal

Coal is used primarily in coke and gas plants in California. The data shown in the energy flow diagram are from Ref. 10.

Electricity

For the most part, electricity in California was generated in 1976 by burning gas and, more importantly, oil. Nuclear, hydroelectric, and geothermal facilities were small contributors. Imported power was derived from out-of-state hydroelectric plants and coal-burning plants in the Four Corners area (dedicated in part to California demand). All information on the flow diagram regarding the electric power sector is from the CEC.[11] The square boxes associated with the smaller sources represent conversion plants. The numbers on either side of the boxes are energy inputs and outputs. They reflect the efficiencies of the various methods of generating electricity.

End Uses

Oil and Natural Gas Liquids

To calculate oil consumption in the transportation sector, we took the total California production of gasoline and aviation fuels* and subtracted the quantities exported.[7,11] The amount of diesel fuel used on public highways was derived from California Board of Equalization Tax data.[12] Data on distillate-type oils used by railroads, bunkering fuels (consisting primarily of residual fuels), and military sales are from U.S. Bureau of Mines.[13] We assumed that distillate-type and residual-type oils used by the military were used for transportation. Although this is not strictly true, the error introduced is small (see Table 3).

*Including naptha and kerosene-type jet fuels.

Table 3. California use of oil and oil products in transportation, 1976.

Product	Energy use, 10^{12} Btu
Gasoline	1249
Aviation fuel	309
Taxable diesel	120
Rail diesel	34
Vessel bunkering oils	
Distillate-type	12
Residual	179
Military	
Distillate-type	18
Residual-type	3.5
TOTAL	1925

Data on the amount of oil used in generating electric power were provided by the CEC.[11] Bureau of Mines data[13] are similar. In the category of nonenergy uses, we included LPG used as a feedstock in the rubber and chemical industries, oil used in secondary petroleum recovery and other processes,[14] and asphalt and road oil.[15] By analogy with national statistics,[3] the use of waxes, lubricating oils, cleaning fluids, miscellaneous hydrocarbons, and medicinal oils was estimated at a level equivalent to one-third of combined asphalt and road oil sales.

Oil used in the residential/commercial/firm-industrial sector* includes combined residential/commercial sales of LPG (chiefly propane),[14] heating and cooking kerosene,[13] distillate-type and residual-type oils used for heating,[13] and miscellaneous "off-highway diesel."[13] Agricultural oil as well as oil used in the petroleum industry are included in the industrial category along with oil used by "interruptible" industrial customers.

Natural Gas

The California utilities'** use of natural gas as a boiler fuel to generate electricity is monitored by the California Energy Commission.[11] Residential, commercial, and firm-industrial data come from the same source. Field and plant use was estimated as 1% of the nonassociated gas and 2.7% of the associated gas by analogy with operational data from the California Division of Oil and Gas District No. 6.[16] Transmission uses and losses were estimated at 4.0%.[17] Net storage information also comes from the California Division of Oil and Gas.[6]

The principal nonenergy use of natural gas is in fertilizer manufacturing. Four large manufacturers in California were canvassed with regard to their NH_3 output in 1976 and the fraction of that output that went into agricultural products such as urea- and ammonia-based fertilizers. The estimate in the flow chart is based on 40 MCF/ton NH_3.[18]

Electricity

The end uses of electricity in California come from the California Energy Commission.[11] Included in the industrial category are agricultural use (largely related to pumping local water) and an "other" category, which represents requirements of large state, federal, and metropolitan organizations that control and transport state water supplies over large distances in aqueducts, canals, and pipelines. Transmission and other losses are the differences between total electric supply and sales to customers.[11]

Efficiencies

Rejected energy in the electrical sector is largely a matter of record, since inputs and outputs of electrical generating facilities are known. Similarly, transmission losses are known. If transmission losses are ignored, fossil fuel power plants in California are 33% efficient. The efficiency is 30% after transmission (Fig. 1). Hydroelectric, geothermal, and nuclear sources are 90%, 19%, and 33% efficient, respectively, if we ignore transmission losses (Fig. 1).

The efficiencies of other major end-use sectors (industrial, residential and commercial, and transportation) are necessarily somewhat elusive. In almost all cases, numerous technologies are included, and efficiencies cannot be associated with a dominant end-use. In the transportation sector, we assume a 25% efficiency level, corresponding to the approximated efficiency of the internal combustion engine. Transportation efficiencies may in fact be considerably less, but they are difficult to estimate. Efficiencies in the industrial sector are arbitrarily set at 75%, in keeping with the assumptions made in other flow diagrams.[2,3,19] Residential and commercial end uses represent a composite of energy sources and uses, of which space heating with natural gas is the largest. An overall efficiency of 70% was assumed. This is a weighted average of efficiencies ranging from 60% (for space heating) to 90% (for electric lighting and home appliances).

*In the firm-industrial category, energy is used primarily for space heating and lighting of industrial facilities.

**Pacific Gas and Electric Co., Southern California Edison Co., Los Angeles Water and Power Co., San Diego Gas and Electric Co., State of California, and others.

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SKM

APPENDIX: CONVERSION UNITS

Energy source	Conversion factor, 10^6 Btu
Electricity	3.415 per MW·h
Coal	22.8 per short ton
Natural gas	1.05 per MCF
LPG	4.01 per barrel
Crude oil	5.80 per barrel
Fuel oil	
Residual	6.287 per barrel
Distillate, including diesel	5.825 per barrel
Gasoline and aviation fuel	5.248 per barrel
Kerosene	5.67 per barrel
Asphalt	6.636 per barrel
Road oil	6.636 per barrel
Synthetic rubber and miscellaneous LPG products	4.01 per barrel

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